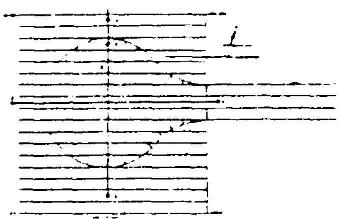
DTIC FILE COPY

(2)

US Army Corps
of Engineers

AD-A227 327



TECHNICAL REPORT GL-90-16

INVESTIGATIONS OF MAGNETIC FIELD DISTURBANCES AT LITTLE ROCK AIR FORCE BASE COMPASS CALIBRATION HARDSTAND

by

Dwain K. Butler, Thomas B. Kean

Geotechnical Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

September 1990

Final Report

Approved For Public Release; Distribution Unlimited

GEOTECHNICAL LABORATORY

Prepared for US Army Engineer District, Little Rock
Little Rock, Arkansas 72203-0867

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Technical Report GL-90-16	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION USAEWES Geotechnical Laboratory 6b. OFFICE SYMBOL (If applicable) CEWES-GG	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 3909 Halls Ferry Road Vicksburg, MS 39180-6199	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING/SPONSORING ORGANIZATION US Army Engineer District, Little Rock 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER IAO No. Mil 90-10
8c. ADDRESS (City, State, and ZIP Code) Little Rock, AR 72203-0867	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Investigations of Magnetic Field Disturbances at Little Rock Air Force Base Compass Calibration Hardstand

12. PERSONAL AUTHOR(S)
Butler, Dwain K.; Kean, Thomas B.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final report	FROM ____ TO ____	September 1990	42

16. SUPPLEMENTARY NOTATION
This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Aggregate
Air Force Base
Calibration hardstand
Compass calibration
Magnetic field

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Investigations were conducted to determine the nature and cause of magnetic field disturbances at the calibration hardstand (compass rose) at Little Rock Air Force Base ~~(LRAFB), Arkansas. The investigations~~ included the characterization of the total magnetic field strength horizontally and vertically both on and off the hardstand with a proton precession survey magnetometer. Also, the variation of the magnetic field strength with time was determined at selected locations on and off the hardstand with a proton precession recording magnetometer. On the hardstand, relative to a nominal earth's magnetic field strength of 53,000 nanoTeslas (nT) at the site, the field is found to vary by as much as 1,000 nT over tens of feet horizontally and by as much as 600 nT over 8 ft vertically. Also, on the hardstand, the magnetic field is found to vary extremely erratically with time by 50-60 nT over periods of a few seconds.

(Continued)

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. ABSTRACT (Continued).

Off the hardstand, the magnetic field is found to be extremely stable, and varies by less than 10 nT over tens of feet horizontally, 8 ft vertically, and over periods of 10-15 min. The magnetic field "stabilizes" at distances less than 25 ft horizontally from the edge of the hardstand. Both on and off the hardstand, the magnetic field variations are independent of the status (on or off) of the nearby ILS System (approach radar).

The results of the magnetic field characterization on and off the hardstand, indicate conclusively that the problem is with the hardstand itself, and not subsurface geologic structure, buried utilities or metal debris, or nearby electromagnetic sources as the cause of the magnetic field disturbance. Examination of a piece of the hardstand concrete reveals that the aggregate is igneous (nepheline syenite) with magnetite as an accessory mineral. The permanent magnetization of the aggregate is sufficient to visibly deflect the needle of a compass. Also, the bulk magnetic susceptibility of the concrete is quite large. The permanent magnetization as well as the large magnetic susceptibility suffice to explain the magnetic disturbances at the hardstand. The time variations can be attributed to induced fields, via the large susceptibility, caused by the combined effects of all nearby manmade electromagnetic sources and distant natural electromagnetic disturbances, including magnetic field variations caused by solar flares and sunspots.

Preface

An investigation of the nature and cause of magnetic field disturbances at the compass calibration hardstand at Little Rock Air Force Base (LRAFB), Arkansas, was authorized by the US Army Engineer District, Little Rock (CESWL), under IAO No. MIL 90-10, dated 19 March 1990. The work was performed during the period 9 April-31 May 1990.

The field work was performed during the period 9-12 April 1990 by Mr. Thomas B. Kean II and Dr. Dwain K. Butler, Engineering Geophysics Branch (EGB), Earthquake Engineering and Geosciences Division (EEGD), Geotechnical Laboratory (GL), US Army Engineer Waterways Experiment Station (WES). Mr. Tim Nipp, CESWL, was the Project Manager for the work, and Mr. Don Tripp, LRAFB, was the Air Force point of contact for the work. This work was performed under the general supervision of Mr. Joseph R. Curro, Chief, EGB, Dr. Arley G. Franklin, Chief, EEGD, and Dr. William F. Marcuson III, Chief, GL. This report was prepared by Dr. Butler and edited by Mrs. Joyce H. Walker, Visual Production Center, Information Technology Laboratory, WES.

COL Larry B. Fulton, EN, was Commander and Director of WES during the publication of this report. Dr. Robert W. Whalin was Technical Director.

Contents

Conversion Factors, Non-SI to SI (Metric)
Units of Measurement

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	metres
miles (US statute)	1.609347	kilometres

INVESTIGATIONS OF MAGNETIC FIELD DISTURBANCES AT LITTLE ROCK AIR FORCE BASE COMPASS CALIBRATION HARDSTAND

Summary

1. Investigations were conducted to determine the nature and cause of magnetic field disturbances at the calibration hardstand (compass rose) at Little Rock Air Force Base (LRAFB), Arkansas. The investigations included the characterization of the total magnetic field strength horizontally and vertically both on and off the hardstand with a proton precession survey magnetometer. Also, the variation of the magnetic field strength with time was determined at selected locations on and off the hardstand with a proton precession recording magnetometer. On the hardstand, relative to a nominal earth's magnetic field strength of 53,000 nanoTeslas (nT)* at the site, the field is found to vary by as much as 1,000 nT over tens of feet horizontally and by as much as 600 nT over 8 ft vertically. Also, on the hardstand, the magnetic field is found to vary extremely erratically with time by 50-60 nT over periods of a few seconds.

2. Off the hardstand, the magnetic field is found to be extremely stable, and varies by less than 10 nT over tens of feet horizontally, 8 ft vertically, and over periods of 10-15 min. The magnetic field "stabilizes" at distances less than 25 ft horizontally from the edge of the hardstand. Both on and off the hardstand, the magnetic field variations are independent of the status (on or off) of the nearby ILS System (approach radar).

3. The results of the magnetic field characterization, on and off the hardstand, indicate conclusively that the problem is with the hardstand itself, and not subsurface geologic structure,

---

*A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

buried utilities or metal debris, or nearby electromagnetic sources as the cause of the magnetic field disturbance. Examination of a piece of the hardstand concrete reveals that the aggregate is igneous (nepheline syenite) with magnetite as an accessory mineral. The permanent magnetization of the aggregate is sufficient to visibly deflect the needle of a compass. Also, the bulk magnetic susceptibility of the concrete is quite large. The permanent magnetization as well as the large magnetic susceptibility suffice to explain the magnetic disturbances at the hardstand. The time variations can be attributed to induced fields, via the large susceptibility, caused by the combined effects of all nearby manmade electromagnetic sources and distant natural electromagnetic disturbances, including magnetic field variations caused by solar flares and sunspots.

Background

4. Problems exist in certifying the calibration hardstand/compass rose at LRAFB for setting/calibrating compasses on the base's C-130 aircraft. The hardstand is close to the parking area for the C-130's and is quite convenient for compass calibration; it is also used for routine turns and for hazardous cargo offloading. Presently, the planes are towed for compass calibration to a stub of the Alert Area, at the other end of the runway from where the planes are parked (about 2 miles). The certification process consists of a detailed assessment of the vertical and horizontal magnetic field variation, and the calibration hardstand has failed to pass certification in recent years. Recollections of base personnel as well as file documentation confirm that "magnetic disturbances" at the hardstand have prevented its routine use since construction in the mid-1950's. A Coast and Geodetic Survey investigation in 1957 concluded (a) that the magnetic field on the hardstand was anomalous and (b) that the range of magnetic declination variation on the hardstand (1.35 deg) far exceeded the Military Specifications for Aircraft Compass Swinging (MIL-C-7834)

criteria (0.2 deg or 15 min) at that time. Base personnel recollect similar concern and investigation of the hardstand in the late 1960's. Documentation exists of considerable concern over failure of the hardstand to pass certification in 1979. Apparently, the hardstand was used intermittently between these dates. Thus, historically, there appears to be about an 11-year periodicity of heightened concern over failure of the hardstand to pass certification for compass calibration.

5. Assignment of a new mission for the Alert Area and current failure of the hardstand to pass certification, presents a significant problem to base operations. The US Army Engineer Waterways Experiment Station (**WES**) was asked by the US Army Engineer District, Little Rock, to perform an assessment of the nature and cause of magnetic field disturbances at the hardstand for the US Air Force. A WES geophysicist visited LRAFB in November 1989 and submitted a Preliminary Assessment (**PA**) of the problem at the hardstand site (Appendix A). The PA recommended a comprehensive assessment of the problem to include: (a) characterization of the horizontal and vertical variations of the magnetic field strength on and off the hardstand; (b) characterization of the temporal variation of the magnetic field on and off the hardstand; (c) determination of the source of the magnetic field disturbances; (d) assessment of alternate sites for possible hardstand relocation. The assessment was designed to identify possible sources of magnetic field disturbance, such as geologic structure beneath the site, buried utilities or metallic debris, magnetic induction from the nearby ILS system (approach radar), natural magnetic field fluctuations from atmospheric sources (such as induced by the solar flare/sunspot activity), or by deficiencies in the hardstand itself (such as the presence of rebar, despite plans and specifications to the contrary).

Hardstand Assessment

Survey layout and procedures

6. The layout of investigations to characterize the nature and source of magnetic disturbances at the calibration hardstand is illustrated in Figure 1. The 400 by 425 ft (122 by 130 m) gridded area was used for a survey of total magnetic field strength over the hardstand and immediate surrounding area. Measurement interval was 25 ft (7.6 m) along SW-NE lines, and 12.5 ft (3.8 m) along SE-NW lines, for a total of 595 measurements. Measurements were acquired with a digital proton precession magnetometer, which has an accuracy of 1 nT. Survey lines I and II were used to detect magnetic field effects in the hardstand area due to cycling the nearby ILS system (approach radar) on and off. Measurement interval along lines I and II was 12.5 ft. Locations 1-5 were used for magnetic vertical gradient measurements (variation of the magnetic field in the vertical direction) during the ILS on and off cycles. Locations 1, 2, 4, and 6 were used for magnetic field versus time measurements during ILS on and off cycles. Magnetic field versus time measurements were acquired with a recording proton precession magnetometer, which produces analog records on a strip chart recorder.

ILS/Approach radar on-off cycling test results

7. The following schedule was followed for the ILS on and off cycling tests on 10 April 1990:

- 0915	ILS On
0915 - 1000	ILS Off
1000 - 1105	ILS On
1105 - 1200	ILS Off
1200 -	ILS On

Profiles I and II were surveyed during both the on and off periods. Magnetic field versus height measurements and magnetic field versus time recordings were made during on and off periods.

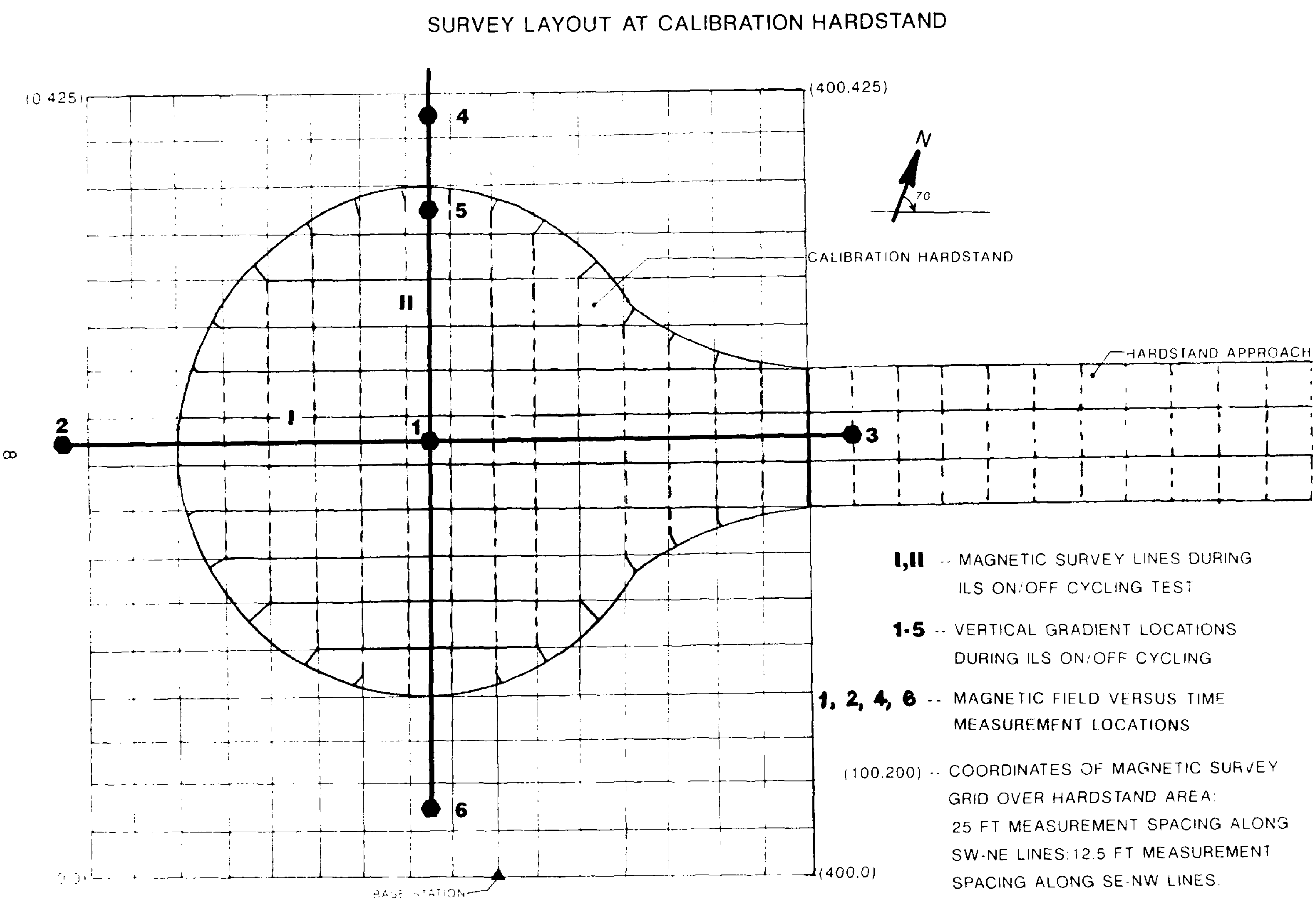


Figure 1. Survey layout at the LRAFB compass calibration hardstand

8. Lines I and II. Results of magnetic field measurements along lines I and II (Figure 1) are shown in Figures 2 and 3. The bottom plot in both figures is for 9 April, with the ILS operating. The top two plots in both figures are for 10 April, during the ILS on and off cycling test. As noted in the PA (Appendix A), the most obvious observation is that the magnetic field strength varies extremely erratically along the lines. Variations of 600 nT or more occur between two measurement locations. Qualitatively, the measurements along the lines are very similar for both days of measurement and for both ILS on and off conditions. However, there are shifts in magnitude: (a) the average or baseline levels are shifted by 100-200 nT between 9 and 10 April and by 25-50 nT between the ILS on and off conditions; (b) magnitudes of some individual peaks or troughs relative to the surrounding magnitudes are shifted, with respect to different days and to ILS on and off conditions.

9. Two low magnetic anomalies are apparent in the line I results (defined by several data values). The first feature is a narrow low anomaly centered at approximately 110 ft of line I and has a half width at half maximum (hwhm) = 25 ft (7.6 m). A broad low magnetic anomaly is centered at approximately 300 ft of line I and has an hwhm = 100 ft (30.5 m). Significantly, the magnetic field strengths exhibit very small variations away from the hardstand and approach constant values, beyond 25 ft from the hardstand. However, the constant values away from the hardstand differ for the time and condition of measurement. This very subdued magnetic field expression off the hardstand was not observed in the PA, since all work was concentrated on the hardstand.

10. Vertical gradients. Measurements of magnetic field strength variations in the vertical direction are shown in Figure 4 for locations 1-5 and for ILS on and off conditions. Three distinct vertical magnetic gradient signatures are displayed. There is no detectable difference in the vertical magnetic gradient for the ILS on and off condition. Locations 2 and 4, off the hardstand, have nearly zero gradient. Locations 1

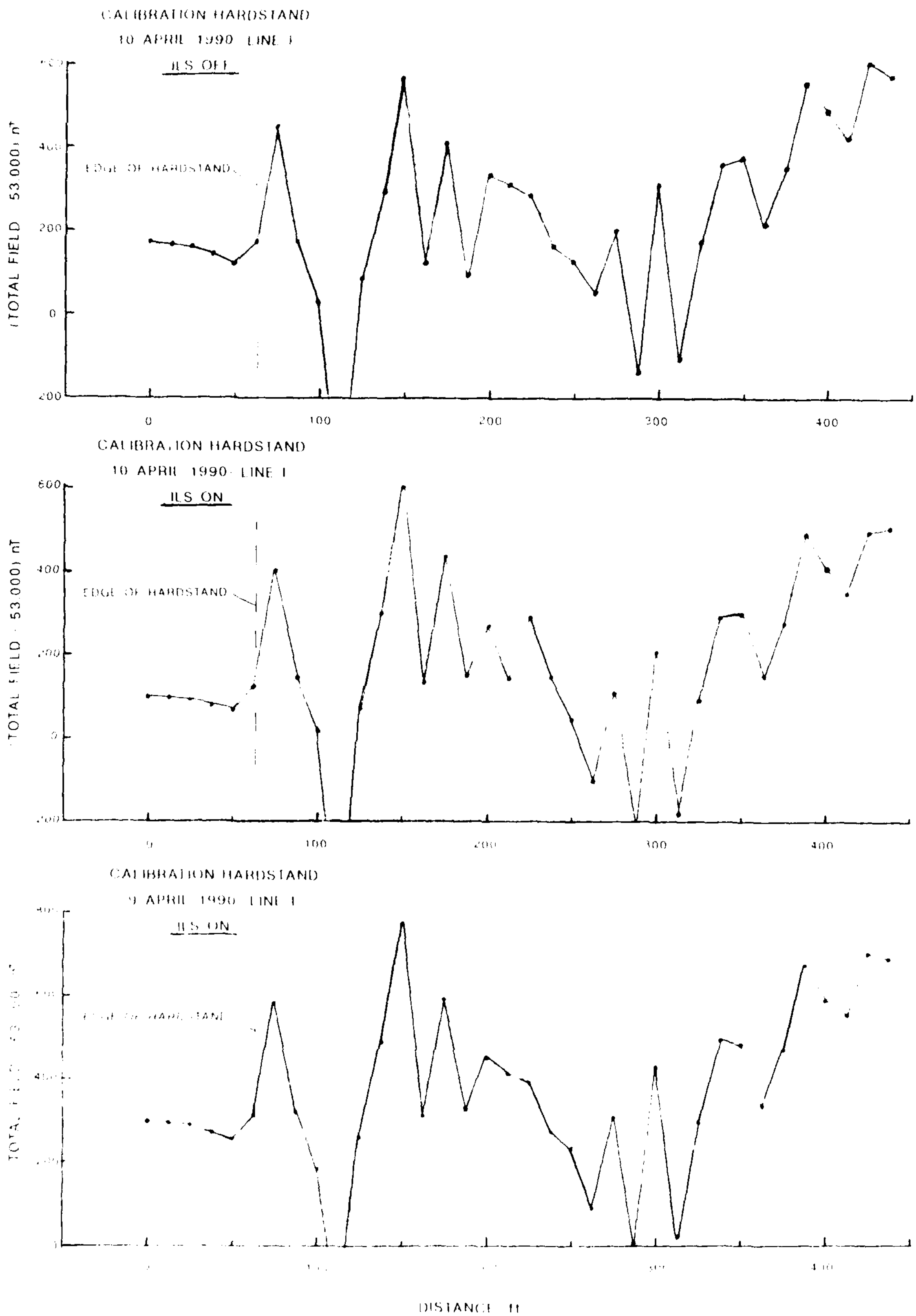


Figure 2. Magnetic field profiles along hardstand line I -- ILS on and off

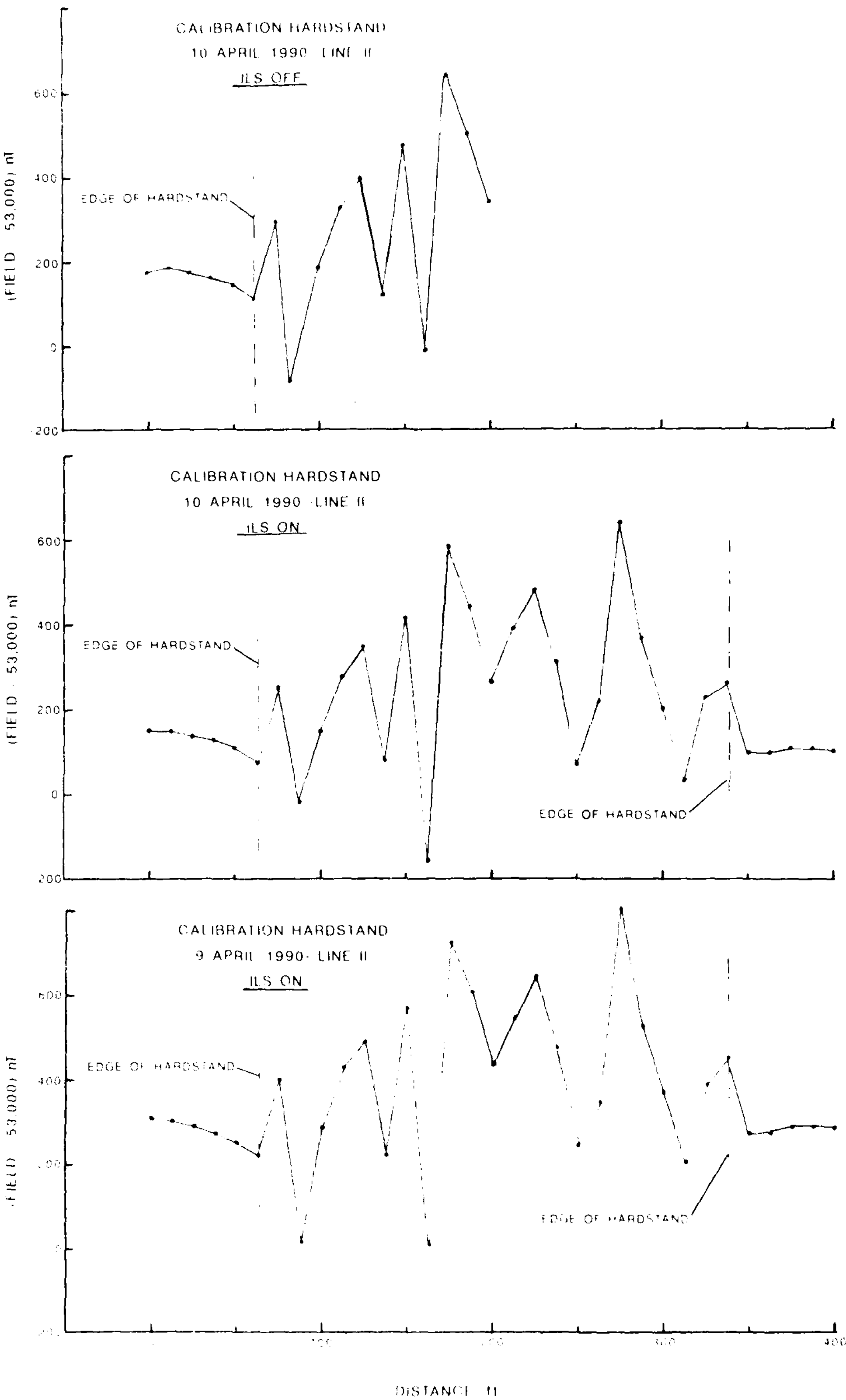


Figure 3. Magnetic field profiles along line II -- ILS on and off

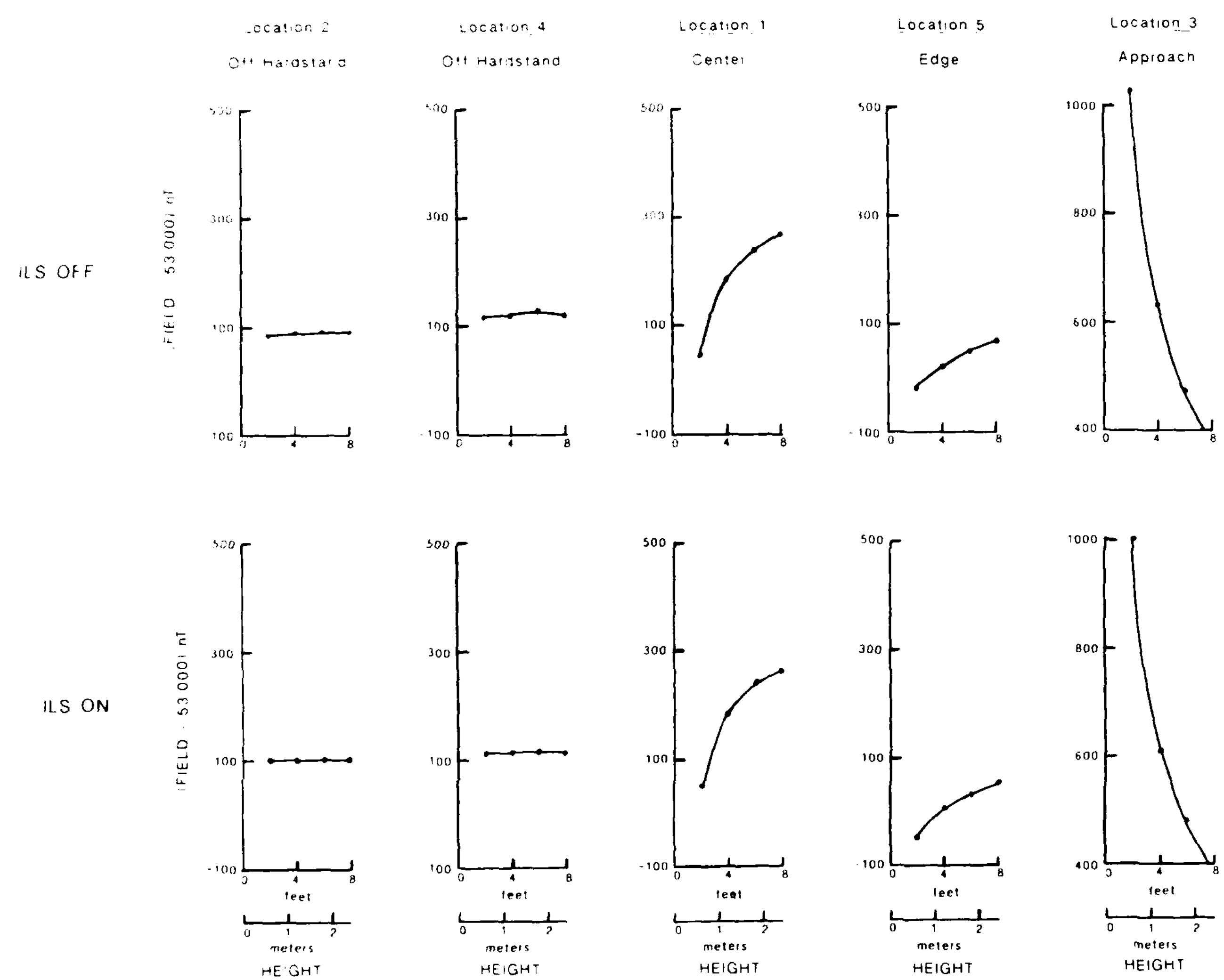


Figure 4. Vertical variations of the magnetic field on and off the hardstand -- ILS on and off

and 5, on the hardstand, have a large positive gradient; whereas, location 3, on the hardstand approach, has a very large negative gradient. These results are consistent with the magnetic profiles in Figures 2 and 3, in that the magnetic field on the hardstand is anomalous; whereas, the magnetic field off the hardstand is subdued and nearly constant.

11. Variations with time. Magnetic field versus time recordings for locations on and off the hardstand are shown in Figures 5 and 6, respectively. The top record in Figure 5 is for 9 April with the ILS operating normally. The remainder of the plots in Figures 5 and 6 are for 10 April and are approximately centered on the time of ILS on/off cycling. No detectable difference is noted between the ILS on and the ILS off conditions. There is, however, a notable difference between locations on and off the hardstand. For location 2, off the hardstand, the record is relatively smooth with 10 nT "spikes" superimposed on a low magnitude cyclical variation with period of 2-3 min; the spikes are likely due to thunderstorm activity in the area on 10 April. The record for location 1, on the hardstand, is extremely erratic and qualitatively appears random. Magnitudes of excursions from a baseline value vary somewhat for the plots in Figure 5 (30-80 nT), but the frequency contents are similar.

12. Figure 7 contains three additional plots of magnetic field strength versus time for locations off the hardstand, all for 10 April and ILS on. These off-hardstand results are consistently different from the on-hardstand results shown in Figure 5. The record for location 6 on 12 April (bottom plot in Figure 7) exhibits no "spikes" (no thunderstorm activity on 9 or 12 April) and has a maximum variation from a baseline of less than 5 nT. Additional recordings of magnetic field strength variations at other locations on the hardstand (not shown) confirm the erratic characteristics shown in Figure 5 for location 1.

Magnetic survey of hardstand area

13. Results of the magnetic survey over the grid area shown in Figure 1 are presented in Figure 8. Intersections of

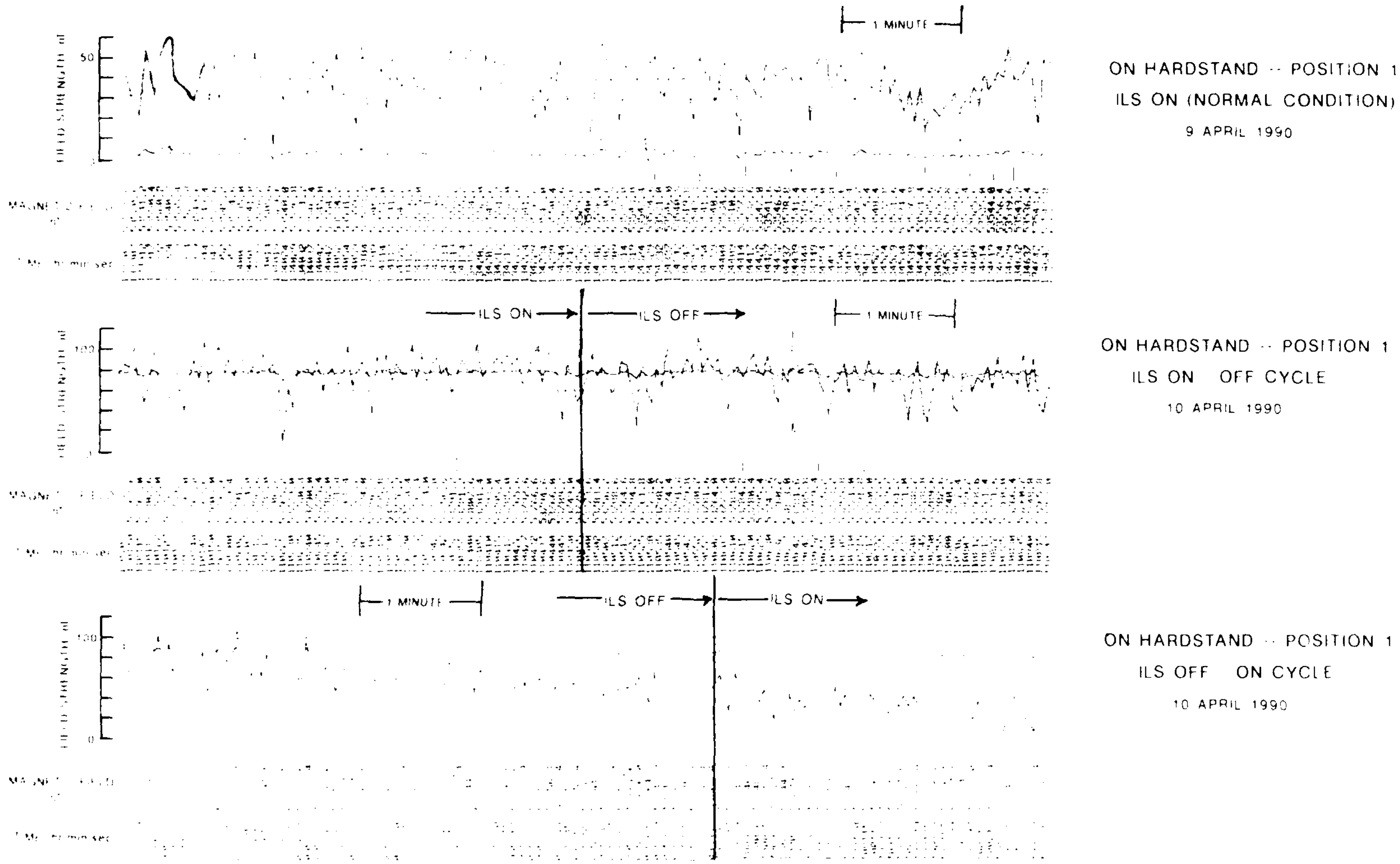


Figure 5. Magnetic field variations with time on the hardstand -- ILS on and off

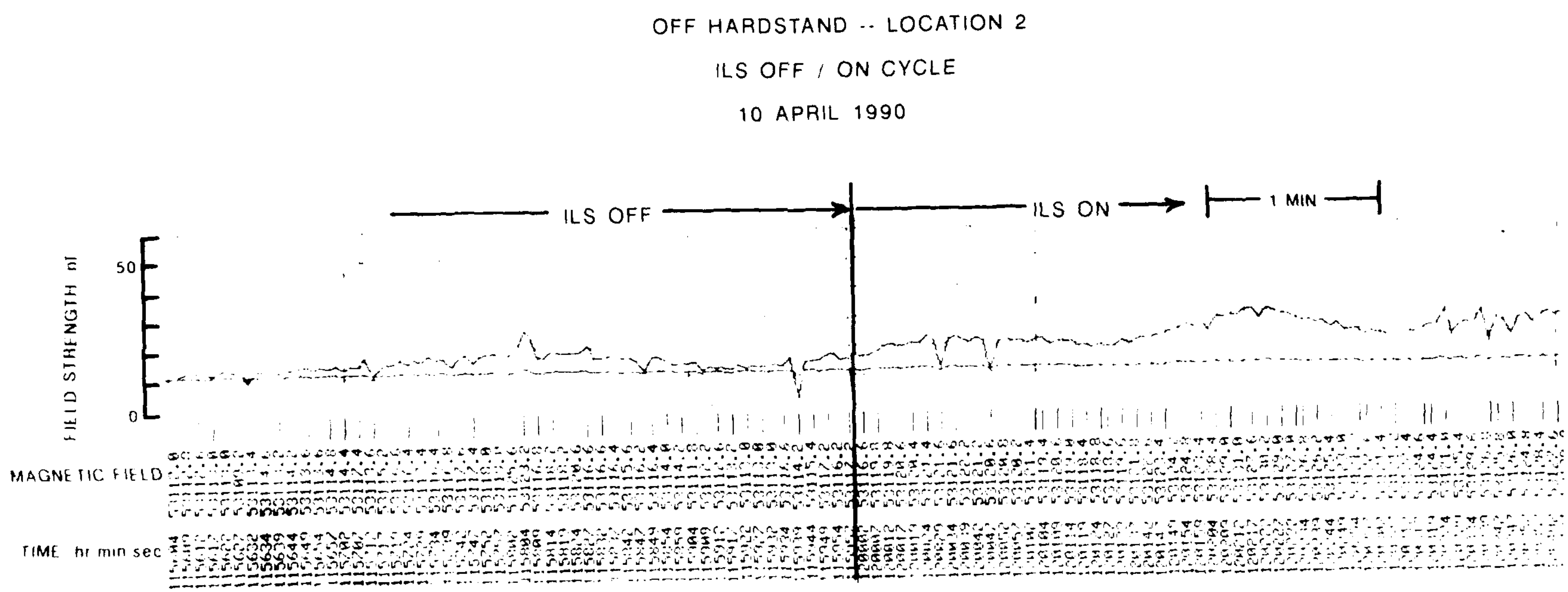


Figure 6. Magnetic field variations with time off the hardstand -- ILS on and off

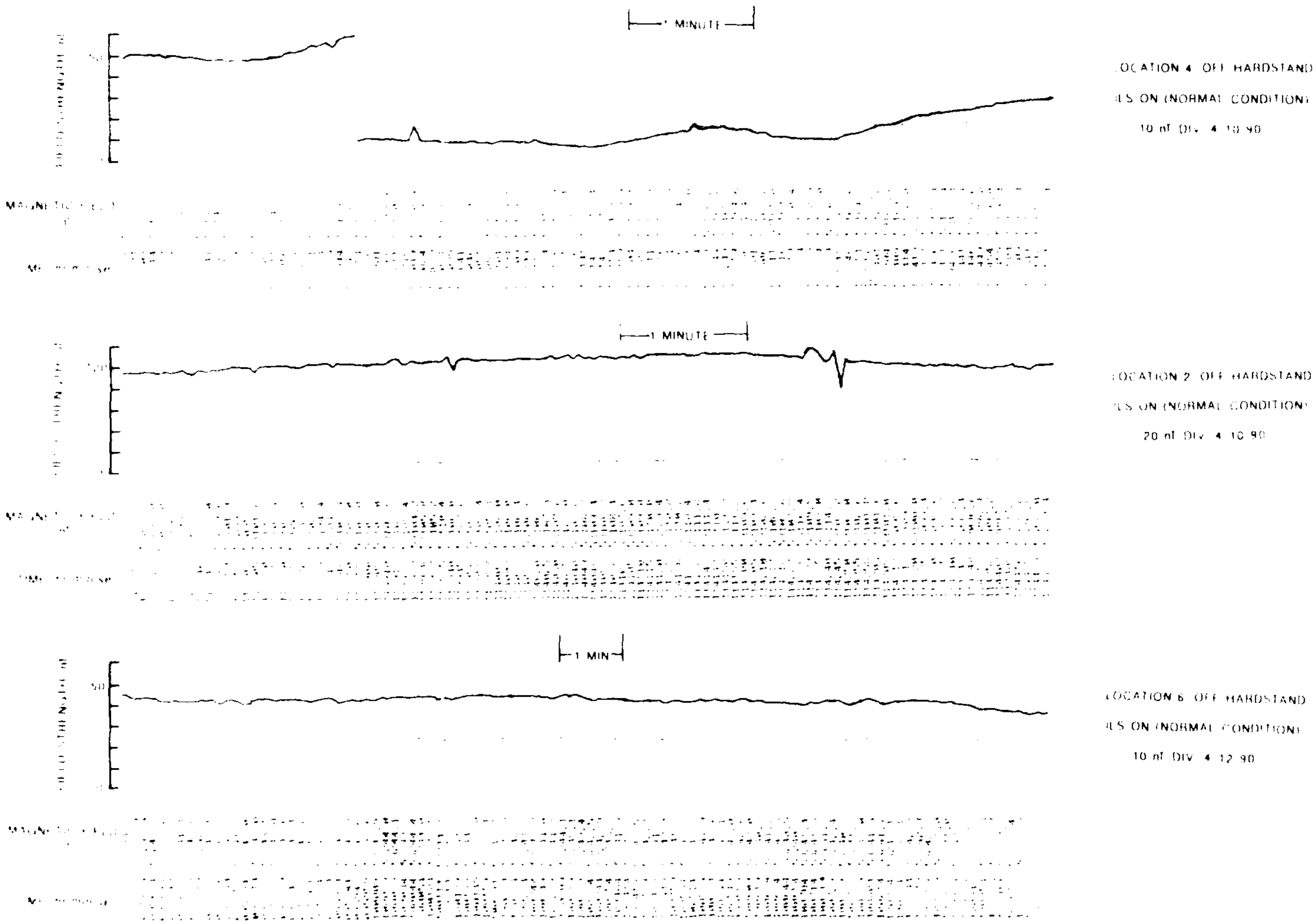


Figure 7. Magnetic field variations with time at three locations off the hardstand -- ILS on

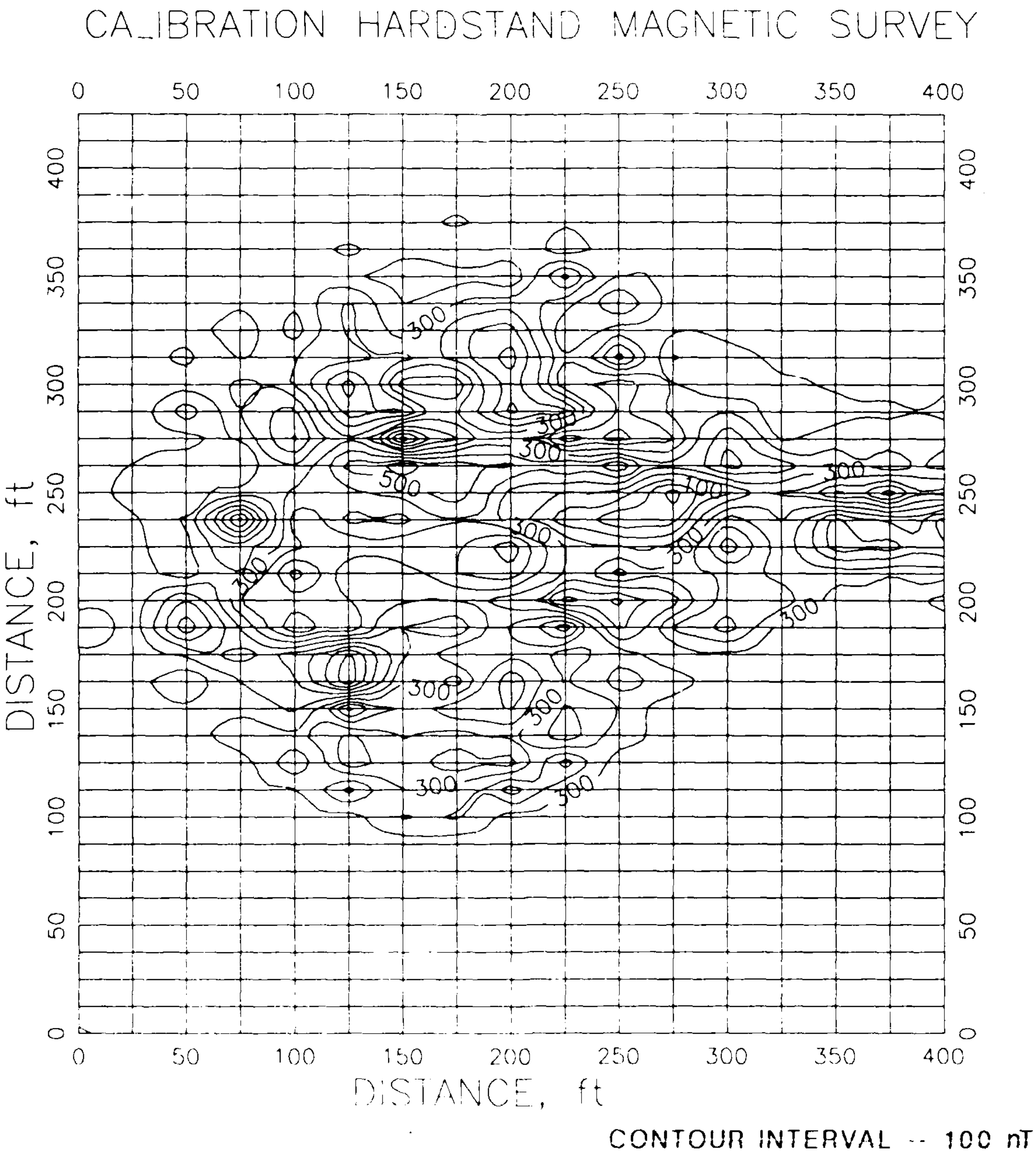


Figure 8. Magnetic anomaly contour map of hardstand area

the grid lines in Figure 8 are measurement points. The base station indicated in Figure 1 was reoccupied at approximately 30-min intervals, and the measurements were used to correct the survey data for time variations, relative to a reference field strength of 53,267 nT. The contour interval in Figure 8 is 100 nT and the maximum and minimum values are 686 and -328 nT, respectively. The extremely erratic nature of the field strength variations over the survey area results in a visually complicated contour plot. The complex nature shown by this contour map proves that the hardstand is highly anomalous; although, the surrounding area is magnetically "quiet." The magnetic contour map is in fact a map of the hardstand; the field varies so little over the area surrounding the hardstand that there are no contour lines off the hardstand.

14. Figure 9 is a plot of the data, produced with a different set of contouring parameters and with a bold zero contour, which illustrates that although the visual appearance of the map may change slightly the essential features are unchanged. There is no clear pattern to the magnetic anomalies on the hardstand. However, most of the low anomaly values are located around the periphery of the hardstand and in the approach to the hardstand, whereas the central region of the hardstand is predominantly a high anomaly area. A possible trend of low anomaly values extends from approximate locations (50,287.5) to (400,250). There is no readily apparent explanation for such a linear trend of low anomaly values. The only evidence of buried utilities in the area is a small, abandoned electric switch box at location (0,187.5), which is indicated by a small magnetic high anomaly. Base personnel maintain that the inactive line (conduit) to the switch box does not pass under the hardstand.

Hardstand assessment conclusions

15. The clear conclusion from all the tests conducted at the calibration hardstand is that the anomalous magnetic field is produced/caused by the hardstand itself. There is no indication that the nearby ILS approach radar is a major contributing factor to the magnetic disturbance. Since there is considerable

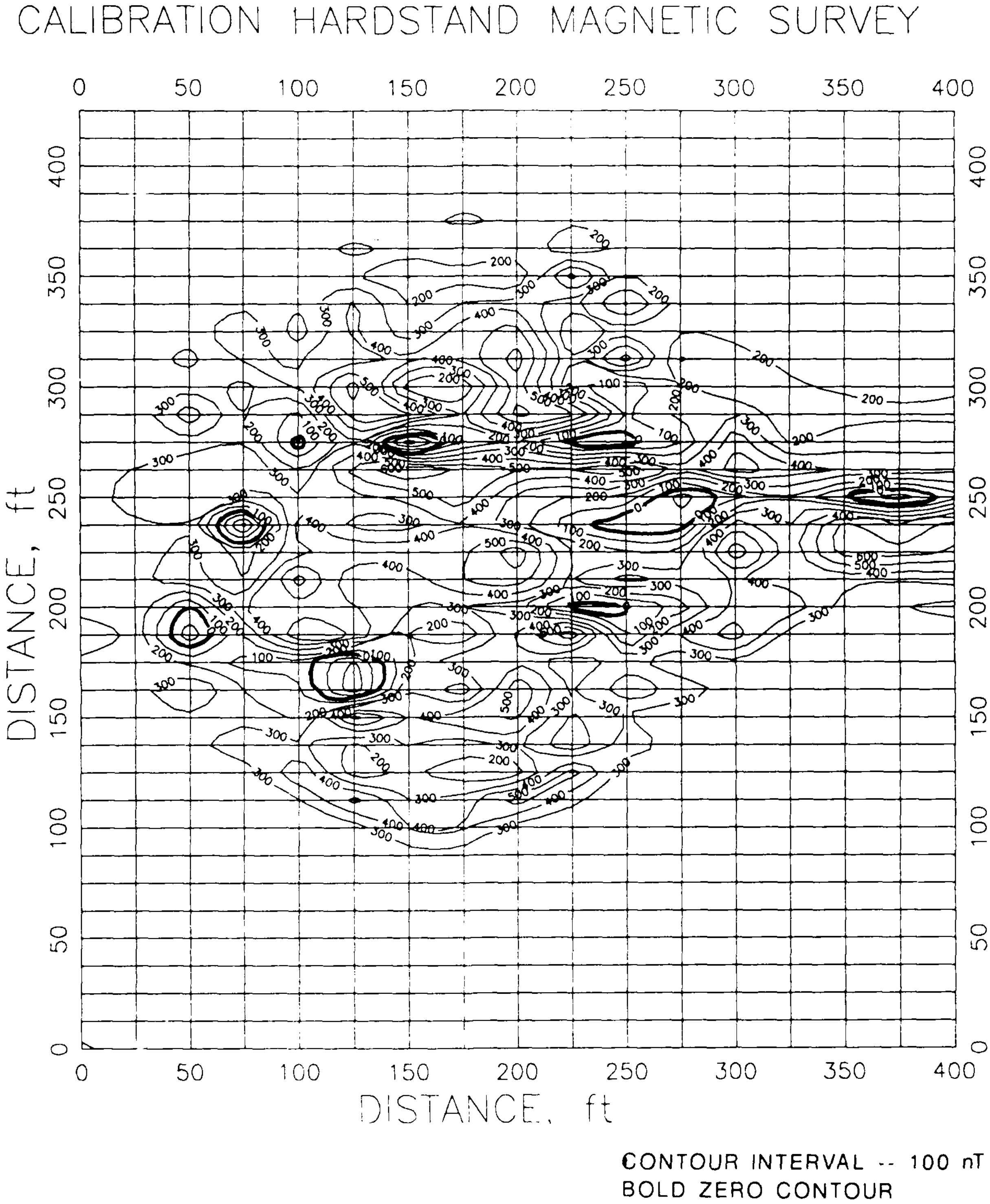
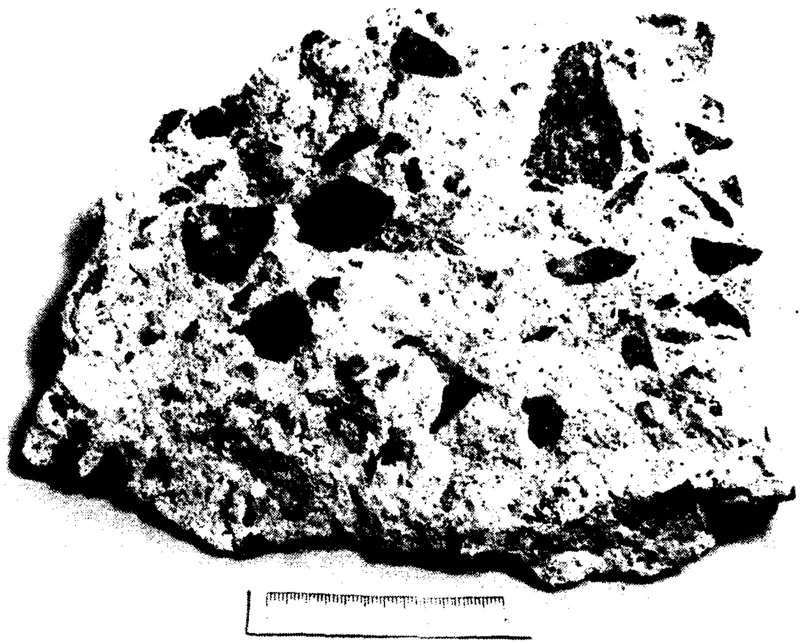


Figure 9. Magnetic anomaly contour map of hardstand area: different contouring parameters than used for Figure 8

horizontal and vertical variation in the magnetic field strength, the character of the hardstand itself must vary in magnetic properties, possibly within each 25- by 25-ft slab. The considerable variations of the field strength with time indicate that the hardstand may have a high bulk magnetic susceptibility (a fundamental property of materials that determines the strength of an induced magnetic field resulting from an applied external magnetic field, in this case the earth's magnetic field). One possible explanation is the presence of rebar in the hardstand; however, design and as-built drawings specify no rebar, and core samples of the concrete taken in the past have not encountered rebar.

16. Examination of pieces of the hardstand concrete reveals that the aggregate is a dark, igneous material (Figure 10). The aggregate is from a well known local quarry, and is identified as nepheline syenite, which has magnetite as an accessory mineral. The permanent magnetization of the samples is sufficiently large to noticeably deflect a compass needle. The following tabulation lists the magnetic susceptibility of two concrete samples and one sample of shale from the Atoka Formation (local "bedrock") determined by the US Geological Survey, Branch of Geophysics, Denver, Colorado:

Sample	Magnetic Susceptibility (micro-cgs units/g)		
	Bulk	Aggregate	Matrix
Calibration hardstand concrete	4.06	6.15	0.78
Alert area concrete	3.92	7.15	1.36
Shale (Atoka Formation)	0.35		



a. Sample of calibration hardstand concrete

b. Close up of aggregate in calibration hardstand concrete

Figure 10. Concrete sample from calibration hardstand; aggregate is nepheline syenite, which has magnetite as an accessory mineral

Thus the bulk magnetic susceptibility of the hardstand concrete is 10 times the susceptibility of the shale "bedrock" and the susceptibility of the aggregate is 20 times that of the shale. Even the concrete matrix magnetic susceptibility is 2-3 times that of the shale. The magnetic aggregate in the concrete is the cause of the anomalous magnetic field on the hardstand. The aggregate has a permanent magnetization due to the presence of magnetite, and the permanent field component can have random strength and orientation due to variations in aggregate "density" throughout the hardstand.* Also, the hardstand will tend to "amplify" time variations of field strength due to thunderstorm activity, nearby electromagnetic sources, and solar activity (flares, sunspots, etc.), due to the high bulk magnetic susceptibility.

17. The correlation of the 11-year periodicity in heightened concern over the hardstand with the known 11-year periodicity in solar activity, with 1990 being the year of a solar activity maximum, is probably not fortuitous. Geomagnetic activity (planetary A values) is quite high during this time period. The Air Force Global Weather Central, Space Environmental Support Section, located at Offutt AFB, Omaha, Nebraska, monitors geomagnetic activity and reports 24-hr and 1.5-hr averages. Geomagnetic activity values for the period of the investigations at LRAFB are listed below:

Day	24-hr Average	1.5-hr Range (0830-1630)
9 Apr	27	22-36
10 Apr	95	82-160
11 Apr	45	25-42
12 Apr	65	30-85

* Headquarters, Department of the Army. 1966. "Airfield Operational and Maintenance Facilities," TM5-824-4. Appendix IX, Para. 4 states that only nonferrous aggregates shall be used in PCC calibration hardstands. Also TM5-822-7/AFM 88 (1987), Chap.8, Para. 5g, gives the same prohibition. Thus, no changes are needed in these documents as a result of this study.

The following classification of geomagnetic activity values is used: 30-49, minor geomagnetic storm; 50-99, major storm; 100-400, severe major storm. Air Force personnel state that compass calibration should not be performed above an activity value of 33.

Alternate Site Assessment

18. The area S-SE of the present hardstand is already indicated as a possible alternate site for construction of a new compass calibration hardstand. Another area indicated by base personnel as a possible hardstand site is indicated in Figure 11, along with magnetic survey lines and recording sites. Results of magnetic surveys along lines I-III are shown in Figure 12. Line I begins in the center of a taxiway, and the magnetic field exhibits an erratic signature on the taxiway (consistent with the hardstand signature) but quickly assumes a nearly constant value off the taxiway. Line I ascends a hill beginning approximately at 260 ft* (approximate el 230) and ends with the last measurement at the top of the hill (approximate el 340). There is no apparent topographic effect on the magnetic field. The magnetic field along the two offset lines (II and III), parallel to the taxiway, is virtually constant.

19. Magnetic field versus time records for the two locations indicated in Figure 11 are shown in Figure 13. The middle plot is a continuation of the top plot for the location on line II, and the bottom plot is for the location on line III. For the first recording location, 100 ft from the taxiway, magnetic disturbances as large as 25 nT from a baseline are created by C-130 aircraft passing on the taxiway. At the second recording location, 225 ft from the taxiway, variation from a baseline is less than 5 nT, and the signature due to a passing aircraft is not apparent.

---

*Elevations in this report are given in ft National Geodetic Vertical Datum (NGVD).

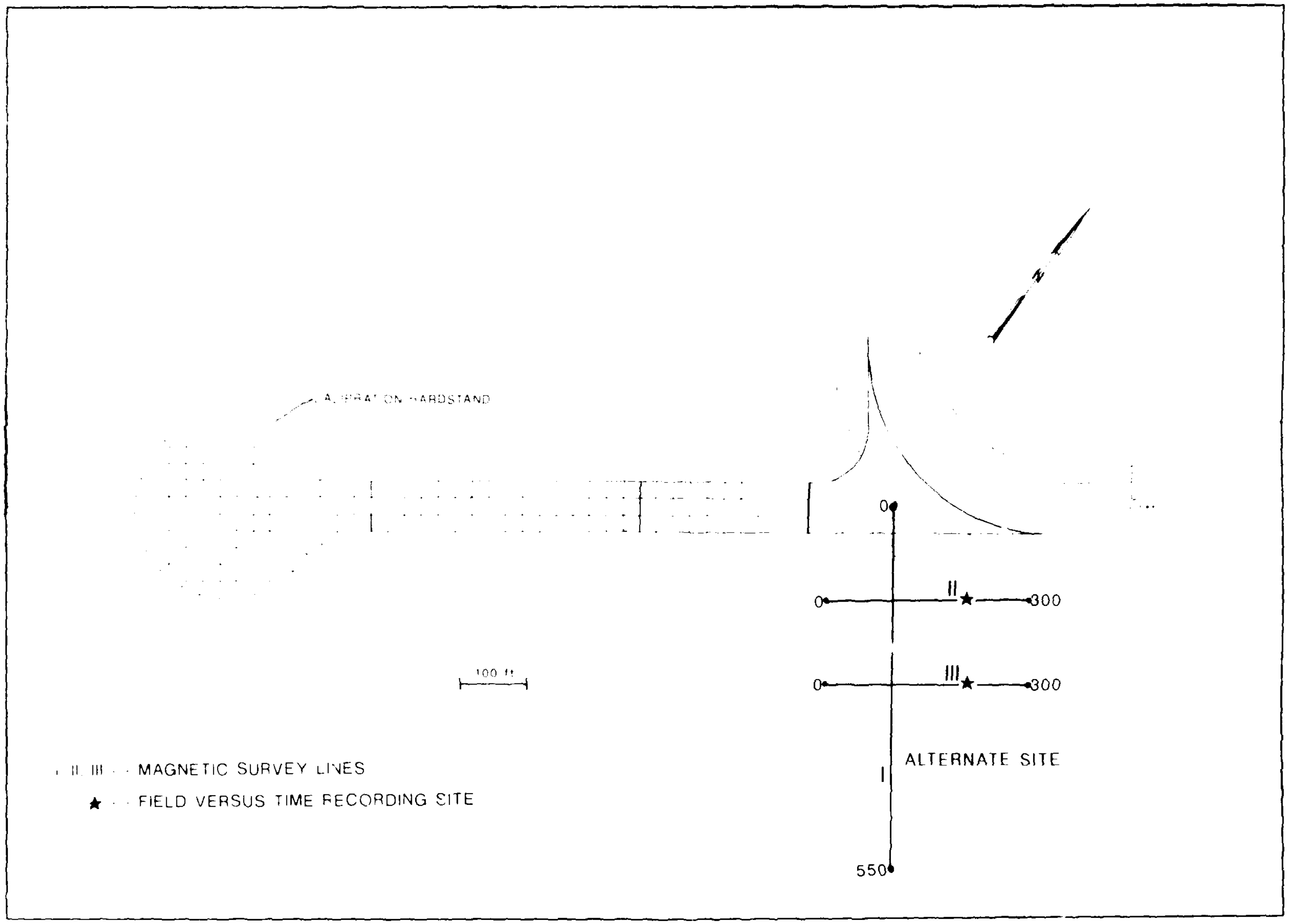


Figure 11. Survey line layout at possible alternate site for hardstand

MAGNETIC FIELD ALONG SURVEY LINES AT POSSIBLE ALTERNATE HARDSTAND SITE

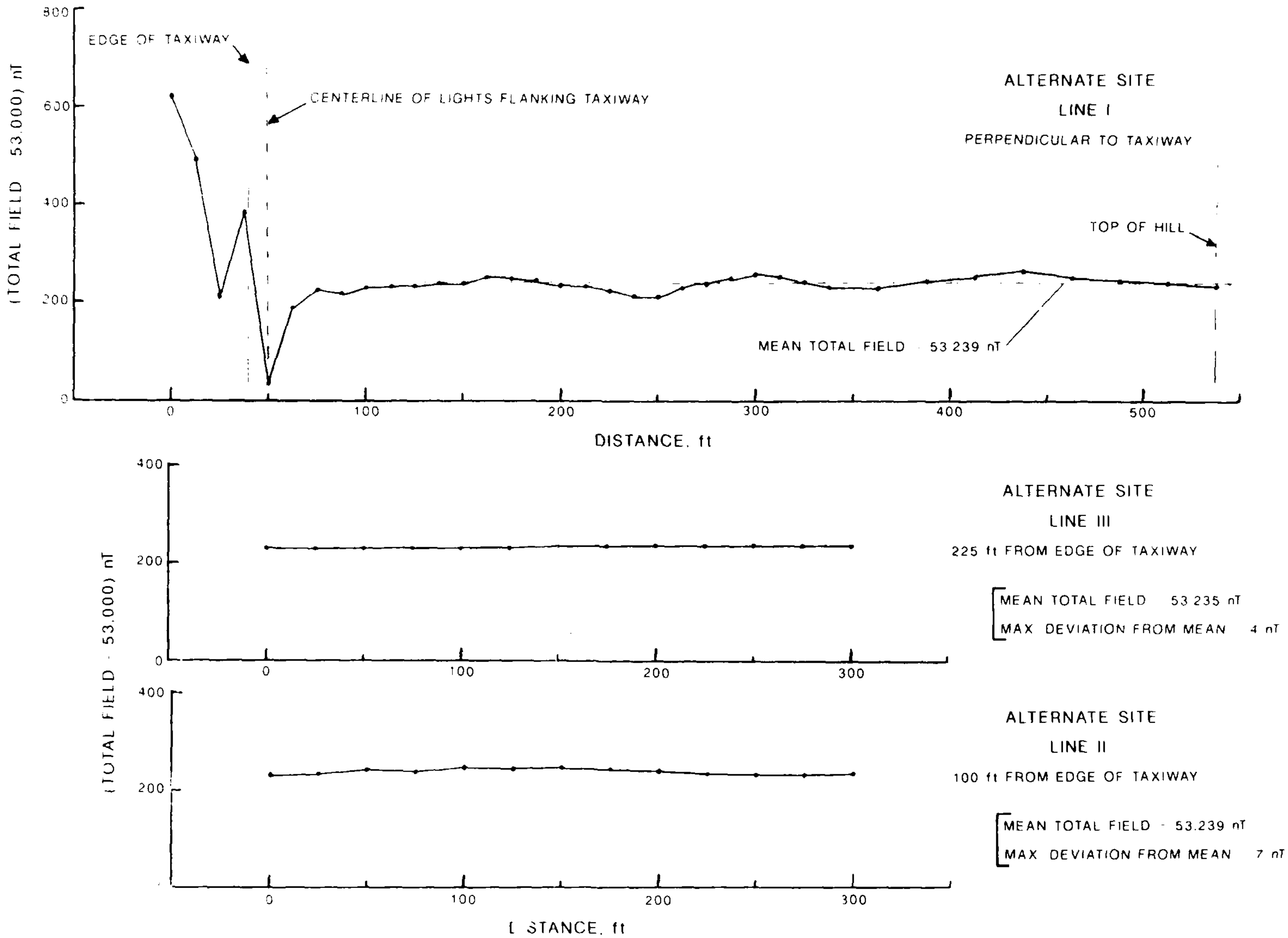


Figure 12. Magnetic field profiles along lines I-III at alternate site

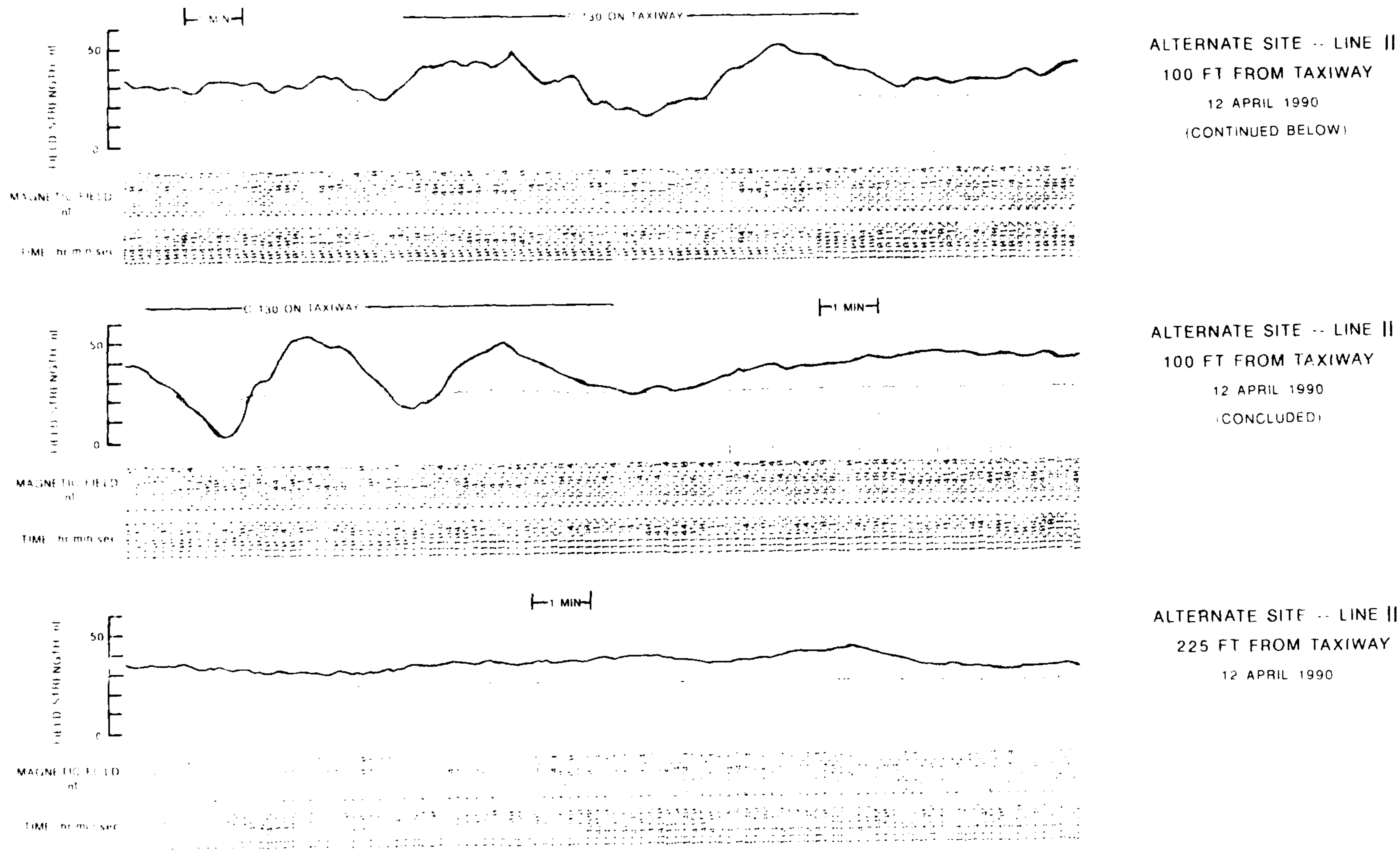


Figure 13. Magnetic field variation with time for two locations at alternate site

20. The alternate site indicated in Figure 11 is apparently an acceptable site for a new hardstand. The closest point on a new hardstand to the existing taxiway should be in excess of 200 ft. Removing the hill to construct a new hardstand should not affect the constant magnetic field characteristic of the area since there is no topographic effect.

Conclusions and Recommendations

21. The cause of the magnetic disturbance at the compass calibration hardstand at LRAFB is the construction material of the hardstand itself. The aggregate in the hardstand concrete and apparently all runway, taxiway, and apron concrete at the base is magnetic. The hardstand concrete has both a high bulk magnetic susceptibility and a variable, permanent magnetization due to the aggregate. This fact suffices to explain all present and past problems with the hardstand and its failure to pass certification.

22. The present hardstand cannot be used for compass calibration. The following options exist:

a. Remove the present hardstand and construct a new hardstand in the same location using nonmagnetic aggregate; a conservative amount of the hardstand approach should also be removed.

b. Construct a new hardstand S-SE of the present hardstand location, using the present hardstand for access, and offset by several hundred feet.

c. Construct a new hardstand at the alternate site indicated in Figure 11, offset by greater than 200 ft from the existing taxiway.

23. Prior to selecting a new hardstand site, Air Force personnel should conduct the normal certification tests in several locations at the alternate sites. If the present hardstand is removed, the normal certification tests and a magnetic survey should be performed at the site prior to initiation of new construction. <u>The new hardstand concrete should use nonmagnetic aggregate.</u> Preferably, both the aggregate and sand used for construction should have magnetic susceptibilities approximately the same or lower than the soils and "bedrock" in the area.

Appendix A

Preliminary Assessment of "Magnetic Field Disturbance" Problems at the Little Rock Air Force Base Calibration Hardstand

27 November 1989

DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
VICKSBURG, MISSISSIPPI 39180-6199

REPLY TO
ATTENTION OF

CEWES-GG

27 November 1989

Mr. Tim Nipp
U.S. Army Engineer District, Little Rock
ATTN: CESWL-ED-P
PO Box 867
Little Rock, Arkansas 72203-0867

Dear Mr. Nipp:

Enclosed is my preliminary assessment of the problem at the calibration hardstand at Little Rock Air Force Base. Please call if you have questions about the assessment itself or about the possibilities for resolution of the problem at the present hardstand site or for location of a new site.

Regards,

Dwain K. Butler
Earthquake Engineering and
Geosciences Division

PRELIMINARY ASSESSMENT OF "MAGNETIC FIELD DISTURBANCE" PROBLEMS AT THE LITTLE ROCK AIR FORCE BASE CALIBRATION HARDSTAND

Background

Problems exist in certifying the calibration hardstand/ compass rose at Little Rock Air Force Base (LRAFB) for setting/ calibrating compasses on the base's C130's. The hardstand is quite close to the parking area for the C130's. Presently, the planes are towed for compass calibration to a stub of the alert area, at the other end of the runway from where the planes are parked (about 2 miles). The certification process consists of a detailed assessment of the vertical and horizontal magnetic field variation, and the calibration hardstand has failed to pass certification in recent years. Some personnel recall 1978 as approximately the time the problems began, which is about the time that a temporary concrete batching plant was removed from near the hardstand. However other personnel recall that there were problems with the hardstand as early as 1965, when the base was used for B58's. The base was completed about 1955. Apparently the hardstand has been used successfully at various times since 1955 for compass calibration.

I visited LRAFB on 7 November, 1989, to conduct a preliminary assessment of the problem with the calibration hardstand. The visit consisted of the following:

a. Meeting with Mr. Tim Nipp, Little Rock District, COE, Mr. Don Tripp, USAF, and Sgt's Richard Griffin and Ken Delahunt, USAF;

b. Brief tour of the base in the immediate vicinity of the hardstand;

c. Limited set of geophysical measurements on and around the hardstand;

d. Demonstration of the calibration certification procedure on the hardstand by Sgt's Griffin and Delahunt;

e. Request for details on locations and frequencies for radar, radio and microwave installations on the base.

Geophysical Measurements

Geophysical measurements were taken on and around the calibration hardstand in order to characterize the variation of the magnetic field horizontally and vertically and to check for the presence of metallic or other electrically conductive materials under or immediately adjacent to the hardstand. The measurements consisted of magnetic field strength, electromagnetic (EM) conductivity, and VLF EM field strength. Magnetic surveys can detect the presence of subsurface metallic objects and also magnetically susceptible geological materials, primarily igneous and some metamorphic rocks. The EM conductivity surveys basically detect electrical conductivity variations, whether due to metals or more or less conductive soil and rock. VLF EM measurements were taken to check for the presence of EM noise in the 15-30 kHz band.

The locations of the geophysical measurements are shown in Figure 1. Lines I and II are N-S and E-W magnetic survey lines with measurements every 25 ft. The squares are locations where magnetic measurements were made as a function of height. The data were acquired with a proton precession (total field) magnetometer with an accuracy of 0.1 nT (nanotesla; the nominal earth's magnetic field strength at the air base is 53,000 nT). Results of the magnetic measurements are shown in Figures 2 and 3. The numbers around the periphery of the hardstand and along a line parallel to the center line of the access taxiway are conductivity values acquired with an electromagnetic conductivity device. The conductivity values represent an averaged conductivity of approximately the upper 20 ft of subsurface material. VLF EM measurements were made at the center of the hardstand and consisted of four scans of the frequency band in directions at 90-deg intervals.

Preliminary Assessment

Discussions with LRAFB personnel indicate that the problems with the hardstand are not recent in nature, thus the possibility of recently installed radio, radar, or microwave transmitters in the vicinity or the installation of overhead power lines or underground pipes or utility conduits are ruled out as sources of the magnetic field disturbance. Also, there has been no change in the type compasses used, the type of aircraft, or in the certification procedure.

The only power line in the vicinity of the hardstand is several hundred feet distant and is not a major transmission line. There are apparently no utility lines or pipes passing under the hardstand. Also there are no visible metallic objects within several hundred hundred feet of the hardstand. The central portion of the hardstand is reportedly formed of unreinforced concrete. Some of the nonrectangular, odd-sized concrete sections around the periphery may contain reinforcement.

The magnetic survey results in Figures 2 and 3 indicate the nature of the problem at the hardstand location: considerable variation of the magnetic field strength both vertically and horizontally. Horizontally, the magnetic field over the hardstand is characterized by gradients as large as 15 nT/ft, and the field is highly erratic. Vertical gradients vary considerably with location in both magnitude and sign:

> Locations 2 and 4 -- different signs, but both magnitudes are approx. = 5 nT/ft
>
> Locations 1 and 3 -- gradient approx. = + 50 nT/ft
>
> Location 5 -- gradient approx. = - 60 nT/ft

A well-defined positive magnetic anomaly occurs with center at location 200 ft of line II (location of anomaly is indicated in Figure 1). The gradient at this location (5) is consistent with a positive anomaly caused by a subsurface source. Based on the width of the magnetic anomaly, the cause of the anomaly could be as deep as 75 ft.

The conductivity is characterized by a value of 13 mmho/m and is quite constant around the periphery of the hardstand. A higher conductivity zone exists is the area of the junction of the hardstand with the access taxiway. The high conductivity appears to be associated with shallow geological materials and not necessarily the presence of metals. Conductivity values in the vicinity of the magnetic anomaly are constant and equal to the normal background value; this implies that the source of the magnetic anomaly is deeper than 20 ft. The conductivity values around the periphery indicate that there are no metallic objects such as pipes passing under the hardstand in the upper 20 ft of the subsurface.

The VLF EM scans were anomalous. In the directions 70 deg E of N and 70 deg W of S, there was no VLF signal or noise at all. In the directions 20 deg W of N and 20 deg E of S, there was

measurable noise across the entire VLF band and the signal from NAA (Annapolis, MD) was identifiable. The cause of these anomalous results was not apparent at the time of the surveys.

A review of a map of radar antennae locations, subsequent to the field work, revealed a radar antenna (B-98) located approximately 1,100 ft NW from the hardstand. The radar operates at 109.9 MHz continuously, and was installed in 1971. The location and frequency suggest the possibility that the radar may be connected with the erratic magnetic field at the hardstand.

Synopsis and Recommendations

A review of conditions at the calibration hardstand indicates the following:

a. The magnetic field is erratic, varying significantly both horizontally and vertically;

b. There is apparently no shallow buried metal beneath the hardstand (< 20 ft);

c. There is a well defined magnetic anomaly close to the center of the hardstand which is likely caused by a feature > 20 ft but < 75 ft deep;

d. A radar antennae located near the hardstand may be the cause of the erratic magnetic field over the hardstand; the EM field from the radar could even cause the magnetic anomaly by coupling with a conductive zone in the subsurface.

A more comprehensive magnetic survey of the area over and around the calibration hardstand is recommended in order to better characterize the magnetic field variation. In conjunction with this survey, a recording magnetometer will be deployed to monitor for magnetic field variations at one location as a function of time. During the recording time, the nearby radar system should be cycled on and off at least twice; the off time would not have to be lengthy (< 1 hr). During the on and off times, the magnetic field would also be repetitively surveyed along at least two orthogonal survey lines in addition to the continuous recording.

In addition to the above effort, any additional areas which are logistically favorable sites for a calibration hardstand could be surveyed to characterize the magnetic field and form the basis for a possible relocation recommendation.

If the Air Force desires to pursue the above recommendations, a detailed proposal will be submitted through the Little Rock District, Corps of Engineers.

DK Butler

Dwain K. Butler
Geophysicist
CEWES-GG
601-634-2127

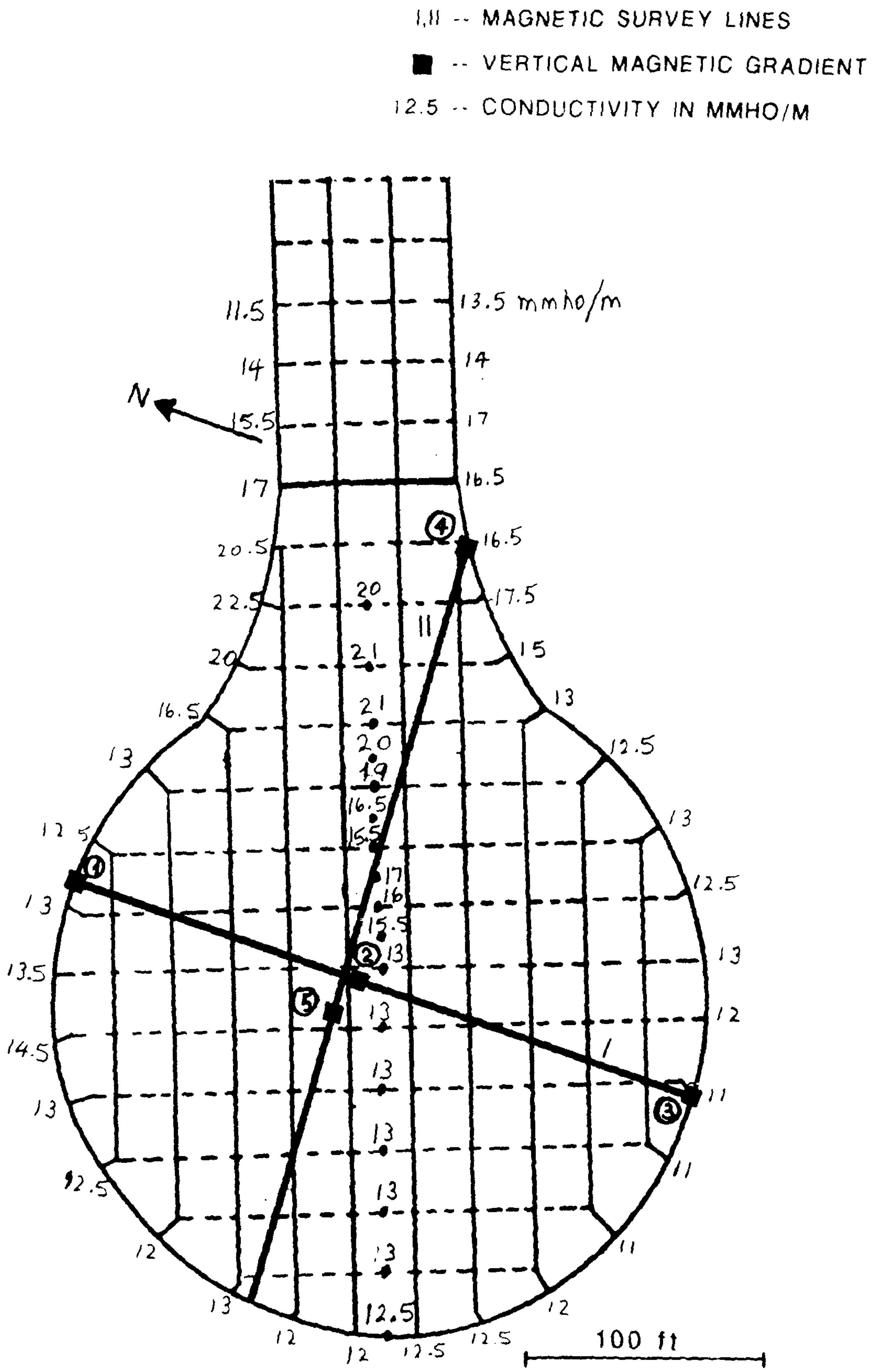


FIGURE 1. GEOPHYSICAL SURVEY LAYOUT AT THE CALIBRATION HARDSTAND

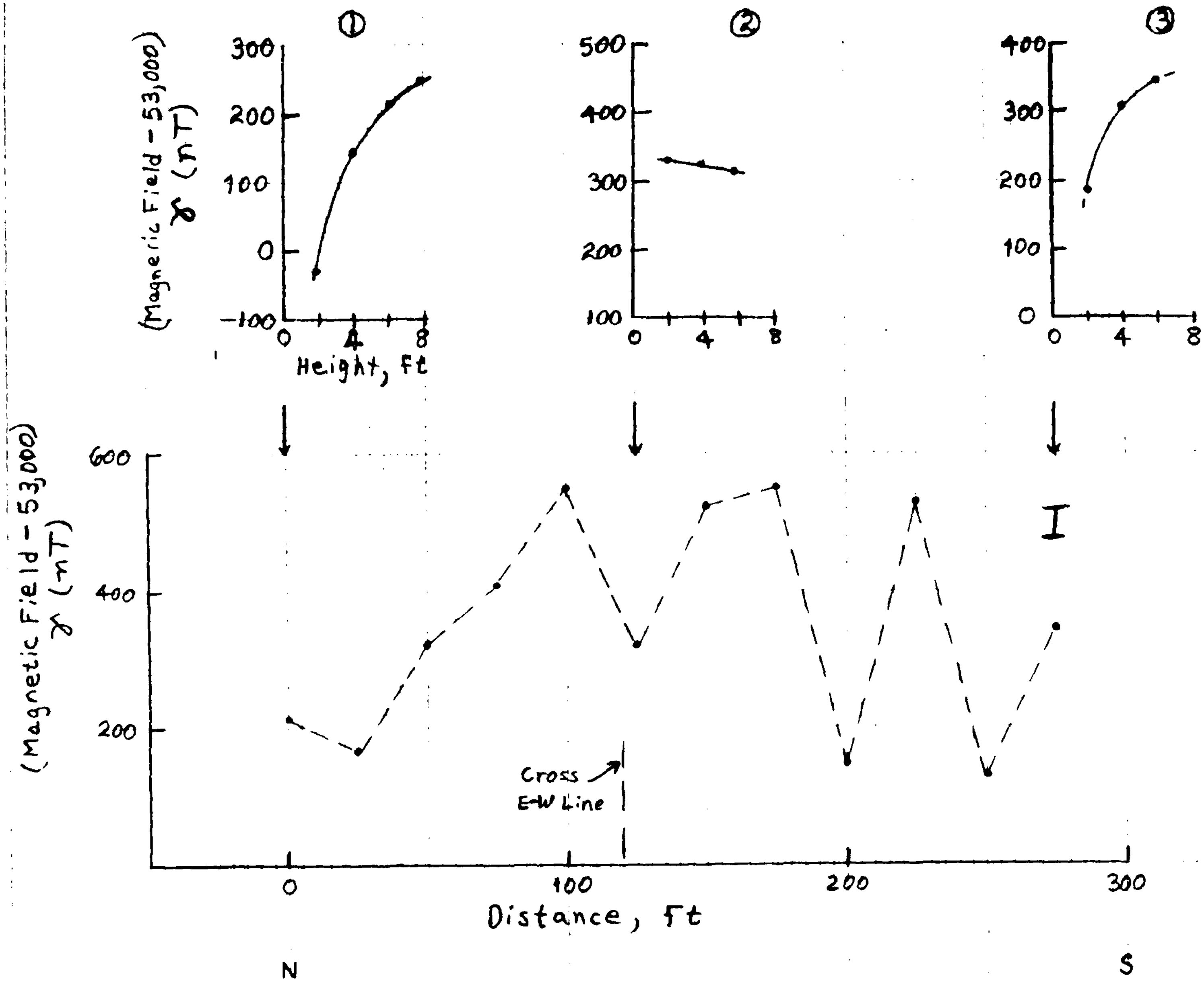


FIGURE 2. MAGNETIC SURVEY LINE I

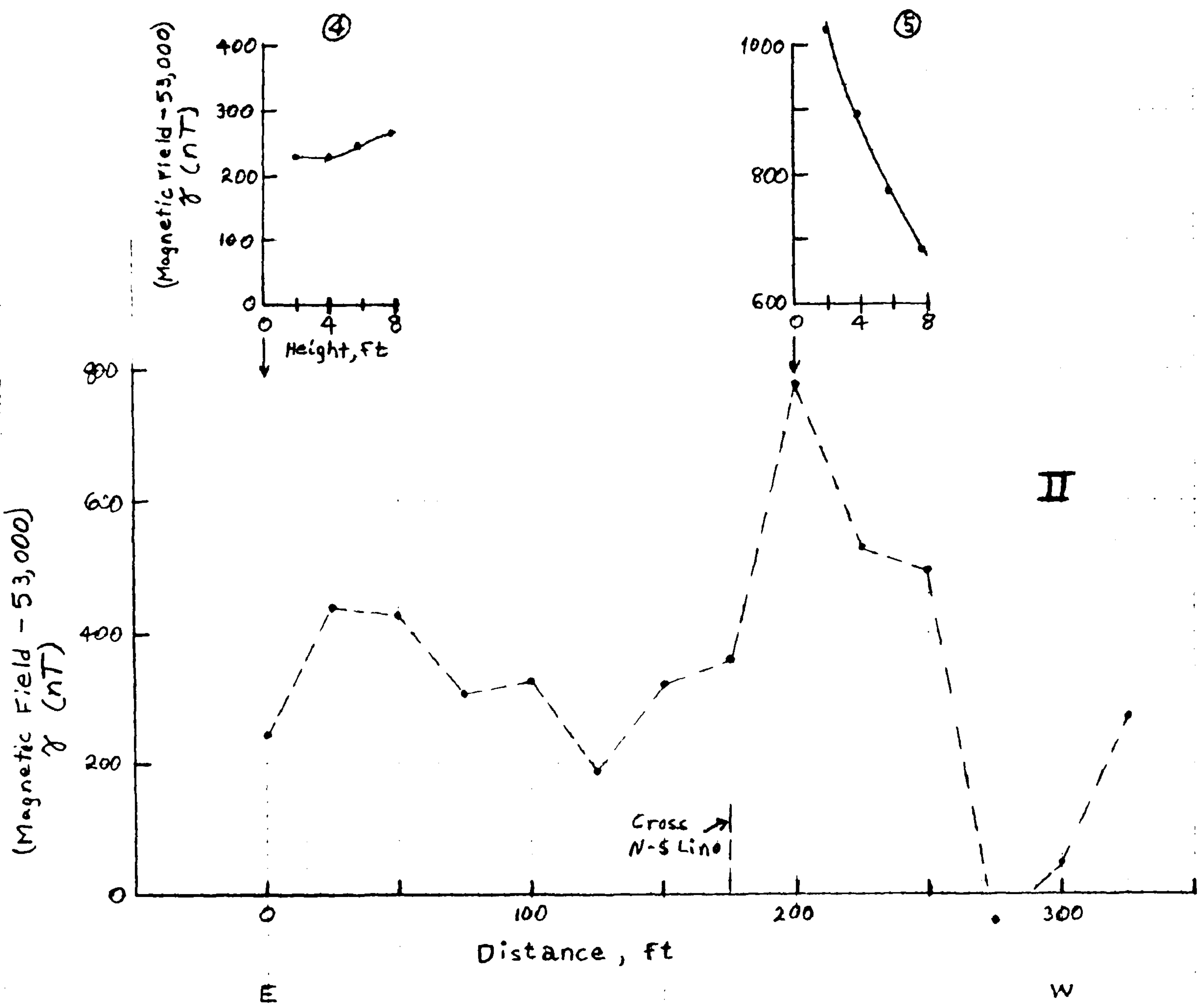


FIGURE 3. MAGNETIC SURVEY LINE II